EXPERIMENTS, MEASUREMENTS AND COMMENTS

ON

REDUCING K_a BAND RADAR ECHOS

FROM

AN AIRCRAFT MODEL

FOIAb3a

[redacted]

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In April 1957 when the [redacted] was first introduced to the problem of reducing 10-cm radar echos from a ________ aircraft emphasis was placed on two aspects:

1. Locate the spatial directions of the major radar echos from this particular target and determine their true relative amplitudes.
2. Identify, if possible, the areas of the target producing each major echo.

The approach to the problem was to be a physical one, rather than mathematical, employing a metallized model target scaled down appropriately to the wavelength of the 0.86 cm radar to be used in the experiments - - a 12 to 1 scale down. Attention was to be concentrated in the directions covering 360° of azimuth and lying between 10° and 45° below horizontal.

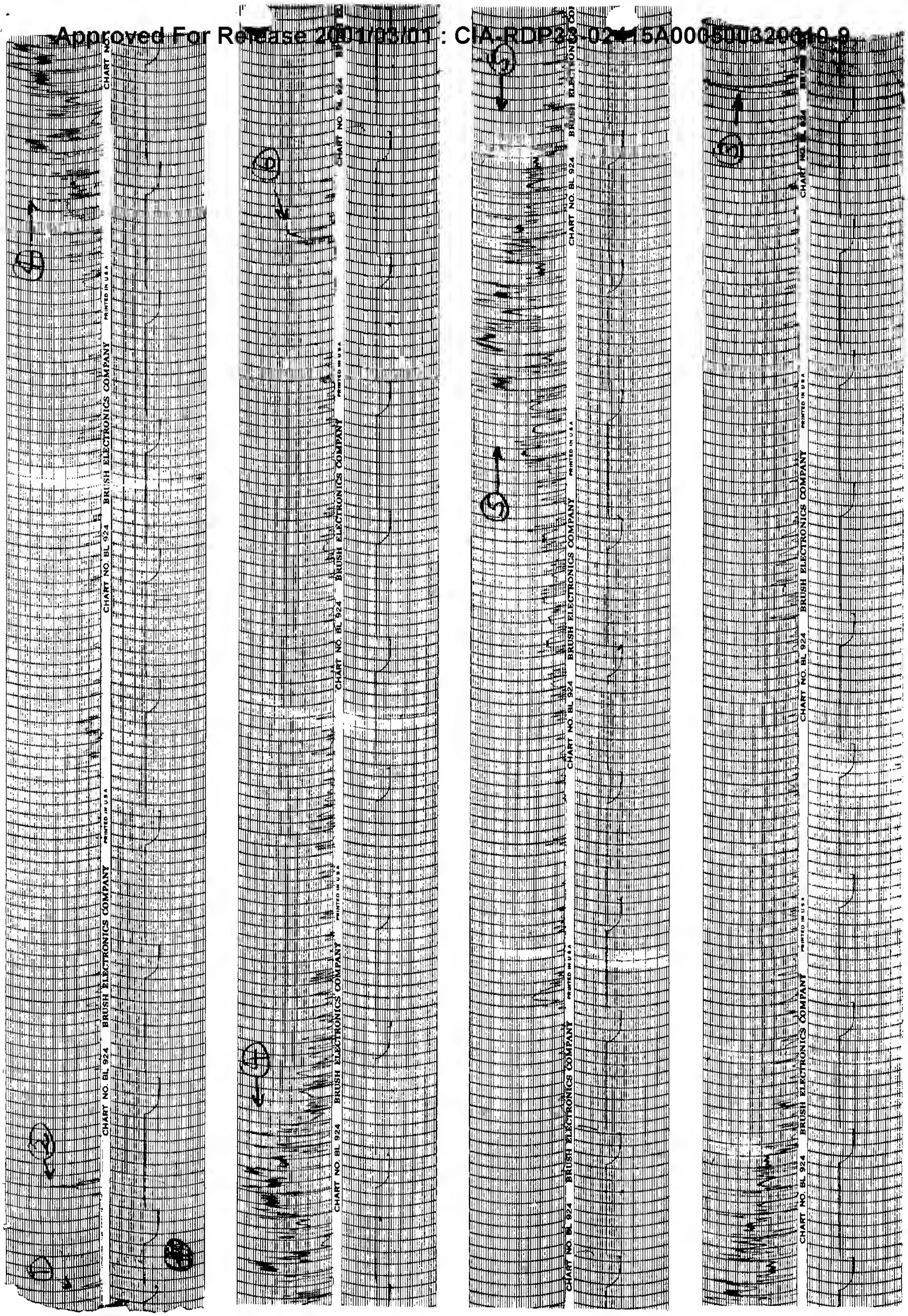
With these goals and parameters in mind a 4500' test range was hurriedly constructed and instrumented with such components as were readily available.

Because of excessive clutter in the vicinity of the target initial results were unsatisfactory. Therefore, the range was reduced in length to 600 feet at the risk of resultant error due to too rapid phase-front and power-distribution changes across the target. The signal to clutter ratio was thereby improved to such an extent that the largest echos from the target were some 15 db above the clutter.

After many measurements and side investigations it was found that the aircraft produced six major azimuth-dependent echos, each fairly independent of elevation angle within the limits of 10° and 45° previously mentioned. These six echo directions are: (1) Nose on over a very small angle; (2) (3) normal to each wing leading edge, which direction is about 10° to each side of the nose, also very narrow; (4) (5) on both sides, normal to the length of the fuselage but wide in angle, some 20°; (6) tail on and also very narrowly distributed. The attached copy of a strip recording demonstrates these echos.

The two echos (4) (5) were dependent on elevation angle near 0° elevation. At 0° elevation the strongest of all echos, that from each side of the rudder, comes into existence increasing the broadside echos some 6 db. over their off-zero amplitude.

After the directions of the major echos were located the target areas contributing to each echo were crudely established. This was done either by removing the suspected area when possible or by covering the suspected area with some 2'inch thick, flexible, hair-batt absorber, and then remeasuring the echo. The nose-on echo (1) appears to be the combined contribution of leading edges of wings and tail. The (2) and (3) echos are from each wing leading edge respectively. The (4) and (5) echos, at broadside to the fuselage, have two particularly strong contributors, the wing-skids and the major body diameter in the area of the wings. Here the rate of body diameter change is zero so that the echo contributions from each body increment are in one direction. The body diameter rate of change over its entire length is such that significant echos are obtained



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over a range of 10° about broadside. The tail-on echo (6) is reflected from the trailing edges of both the wings and the tail.

The two-inch hair batt used to attenuate echos from suspected areas in itself introduced some problems. When 2" hair covers one half the circumference of the model's body, for instance, the "view" from broadside is not that of an attenuated five-inch diameter body, but that of an attenuated nine-inch diameter body. When two-inch batt is used to cover the inside corner of the wing skid, it doesn't really cover this corner, it fills it. In no case is a truly scaled effect achieved. In spite of these shortcomings it is felt that the major echo-generating areas have been identified on the __________. Two-inch hair batt reduced the echos to the power level of the clutter, which was some 15 db down.

Having accomplished the original simple goals, the group was then asked (1) to prove that the various attenuations could be achieved with made-to-order scaled absorber instead of unrealistic two-inch hair batt and (2) to show how to physically shape and place the scaled absorber for maximum advantage.

FOIAb3a A supply of 12 x 12 inch x .033 thick sheets of made-to-order 0.86 cm. absorber was obtained from [redacted] Some of it, aluminum-foil backed, was attached to the model over the suspect areas and echo measurements renewed. As these progressed, results inconsistent with themselves and inconsistent with measurements made when using hair appeared. It was decided that either the scaled material was not acting as it was supposed to, or that the [redacted] did not know how to use it or both. Consequently, a series of simplified experiments was initiated.

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A short 1[illegible] foot range was assembled and a variety of targets prepared for use on this range. These targets were six-inch long aluminum cylinders of 1.3, 3.[illegible], and 6.50 inches diameter and flat sheets of aluminum of various sizes up to 6 x 6 inches square. These targets were measured for echos both as bare metallic items and as absorber-covered items with many configurations of the absorber. Some detailed results of these experiments are shown by the accompanying curves.

Comment on the results of these 1[illegible]-foot range experiments is in order. It was found that the attenuation of any one sheet of scaled absorber is dependent on the shape of the surface to which the absorber is attached. The same piece of absorber placed consecutively on the curved surfaces of the three different diameter cylinders showed decreasing attenuation with decreasing diameter. The attentuation with respect to the bare surface was [illegible] db less when the absorber was cemented to a 1-[illegible]/[illegible] inch diameter cylinder than when the absorber was attached to a flat sheet.

The attenuation of the absorber for any one constant shape is highly variable from sheet to sheet, from spot to spot on a single sheet and from orientation to orientation of a single spot. The extremes of these variables bring about attentuation differences of as much as [illegible] db.

On cylinders it was found that the transition from absorber-covered areas to bare metallic areas must have special attention or echos larger than those from the bare cylinder alone can arise. What is meant is that in covering part of the circumference of a cylinder with absorber the two edges must change from absorber to no absorber gradually over a range of 40 or 50 degrees of arc. An abrupt change occupying 6° of arc

gives rise to severe echo amplitude variations on each side of the transition. (See Figure 1A) The peaks of these echo variations on the bare side of the change are higher than the echo from a completely bare cylinder and the peaks on the covered side of the change are also higher than the amplitude of an echo obtained from a completely covered cylinder. When the transition from bare to covered is accomplished gradually through the use of "scallop" or "shark tooth" serrations at the edge of the absorber these echo fluctuations are reduced to practically zero except for the appearance of one very deep null. See the figures attached which demonstrate the abrupt as well as the gradual transition from "bright" to "dark", Figures 1, , 3.

The null occuring in the region between covered and bare is a consistent event on all diameter cylinders and for all degrees of gradual transition. Over a range of 7[illegible] the null has been found non-frequency sensitive. It is felt that this null can be put to advantage by orienting the absorber's scalloped edges on a cylinder (aircraft body) at one particular angle so that the reduction of echo with changing elevation angle (due to range change) compensates for increase of echo with decreasing range.

For the arbitrary choices (1) that the ______ aircraft can be first detected at a slant range of 50 NM at an altitude of [illegible]0,000 feet and (2) that its echo, as range decreases, should be kept as low or lower than when first detected; the optimum placement of the scalloped edges has been deduced. See Figure 4. For this example the transition angle of the scallops should be about 40° of arc with the peak of the absorber scallop at 10° above the horizontal and the valley at 30° below the horizontal.

This arrangement should be altered to suit actual expected tactical conditions and the characteristics of the particular absorber in use. Figure shows an arrangement of absorber which widens the null, thereby increasing the angular range over which the echo is reduced below the arbitrary detection level.

Through the use of the 1 -foot range it was also found that joints in the absorber covering with effective gaps as small as 1/30 of a wavelength can deteriorate the performance of a covering noticeably. See Figure 6 showing the effects of a gap. The electric vector was normal to the gap. If a simple straight joint cannot be made to produce an effectively zero gap, then an effectively zero gap can be made with a scalloped or serrated joint. Such a scalloped joint with a deliberate gap of about one sixth of a wavelength was found, upon measurement, to be an effectively zero gap. The scallops were crudely cut at about two wavelengths wide and high.

Having learned a useful collection of facts about the scaled absorber and its application the group then decided to select by measurement the fraction of the available scaled absorber which gives sufficient and consistent absorption. This selected fraction will be carefully applied to one side of the recently-acquired precision model of the __________. Measurements covering the prescribed range of elevation angles will then be made on a 400' range now being constructed and equipped. It is expected that this range will have more accuracy, more stability, less clutter and much more speed of data acquisition than was previously the case. With it both the initial simple objectives and the later more difficult ones should be more readily reached for the __________ aircraft as well as for any other similar scaled target.

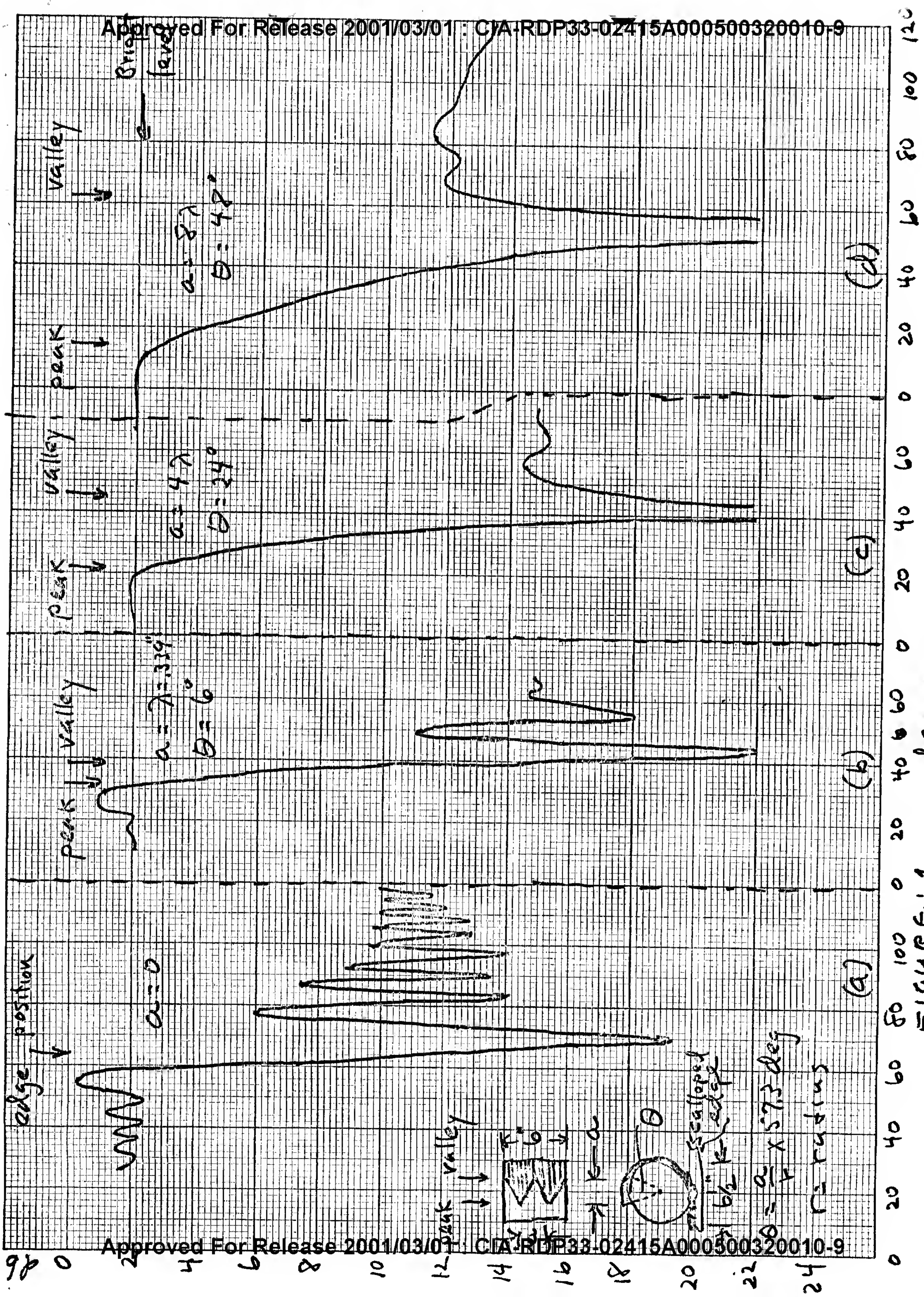

FIGURE: 1

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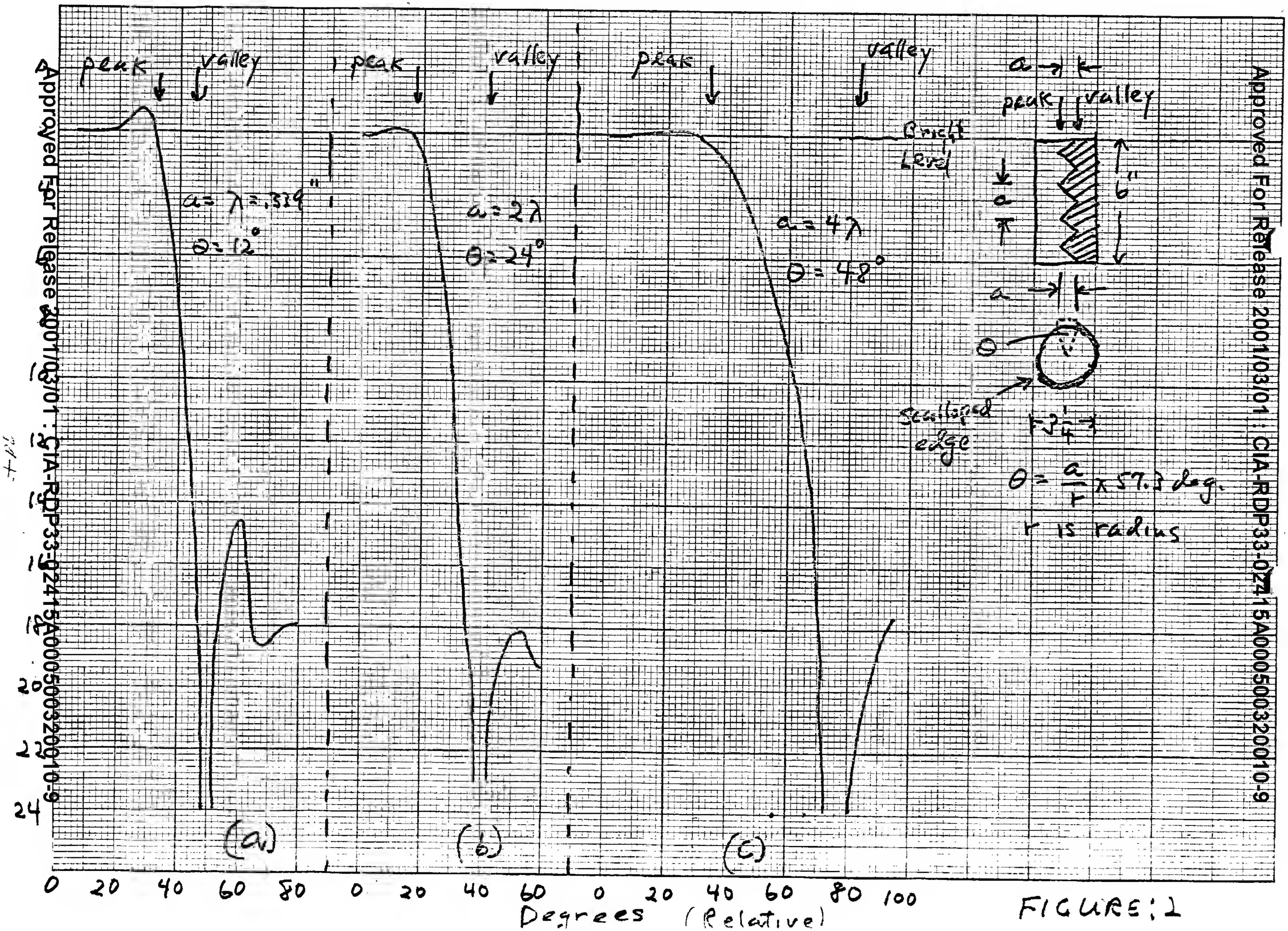

FIGURE: 1

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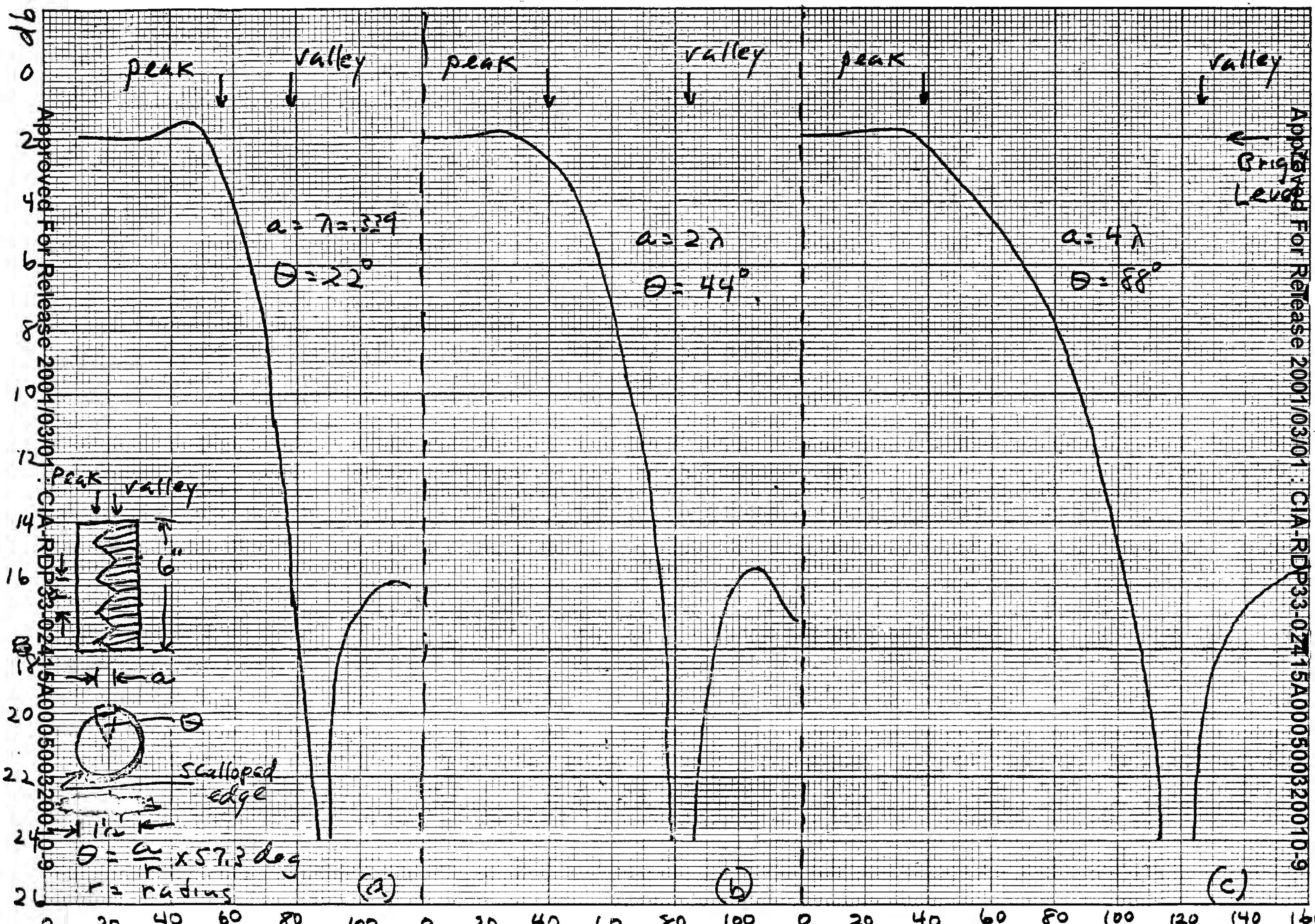

FIGURE 13

degrees

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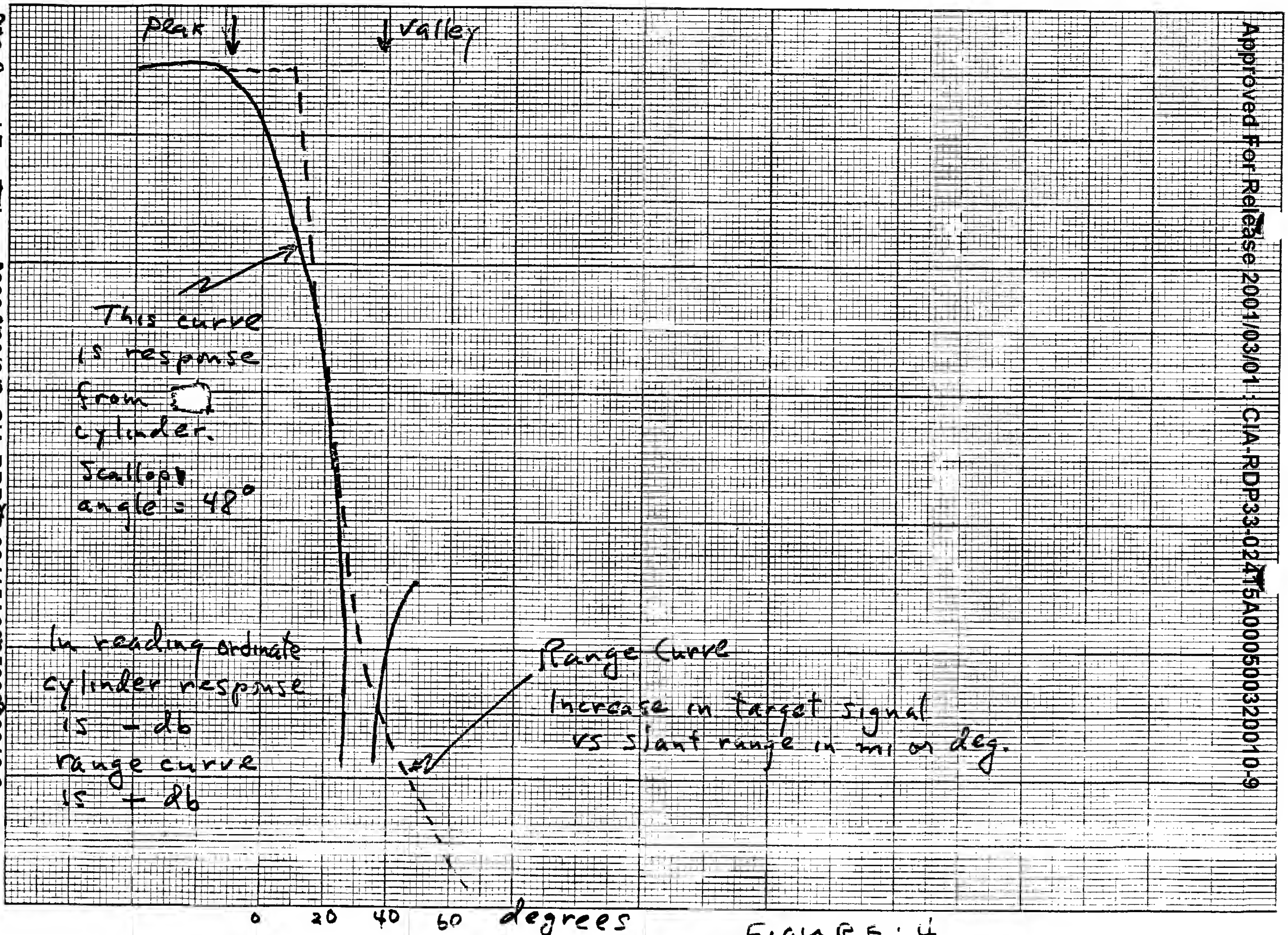

FIGURE: 4

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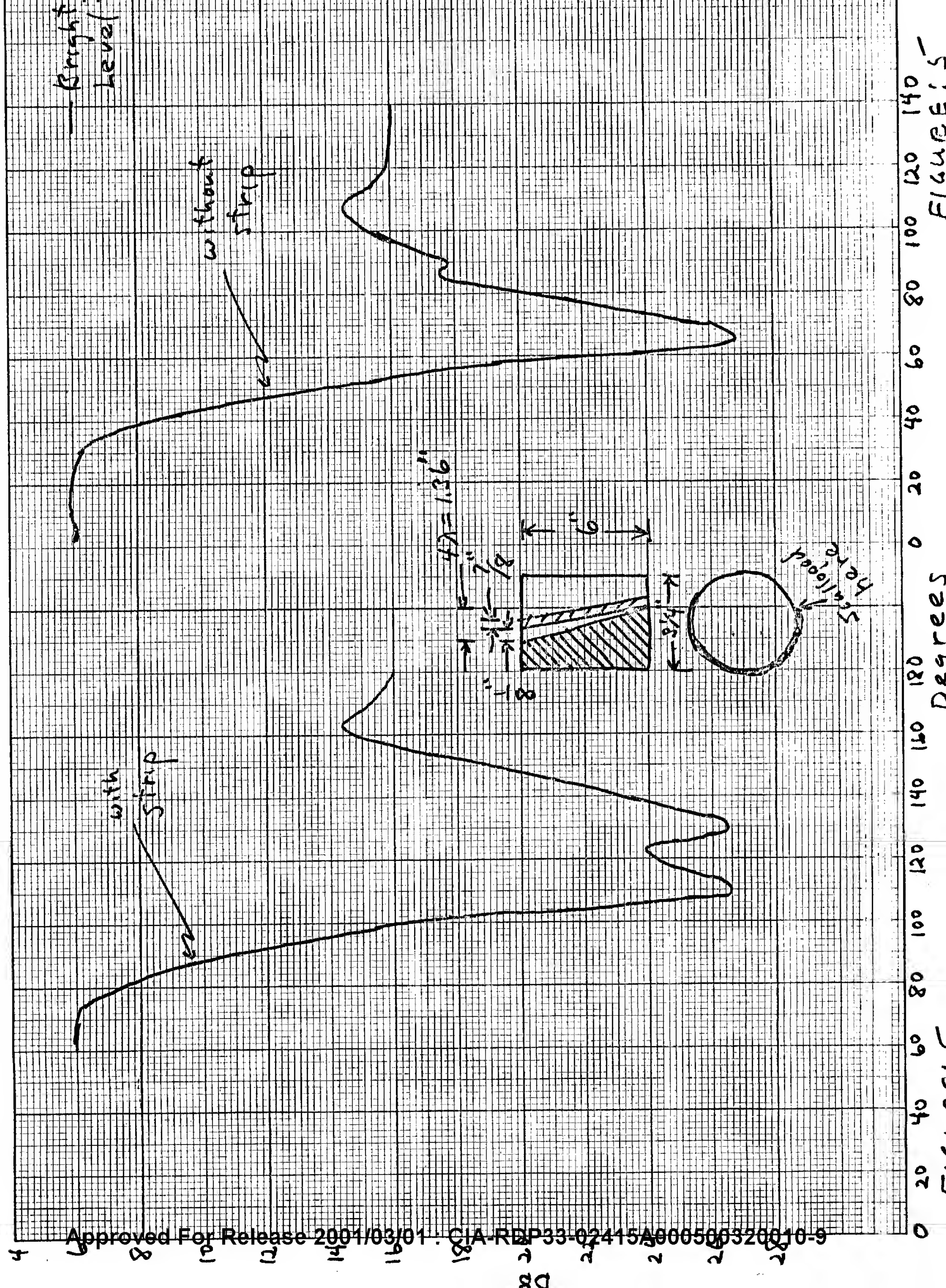
Bright Level
without strip
with strip
D = 1.36"
6"
7/8"
1/8"
1/8"
2 1/4"
Shellac Paint
Degrees
FIGURE: 5
FIGURE: 5

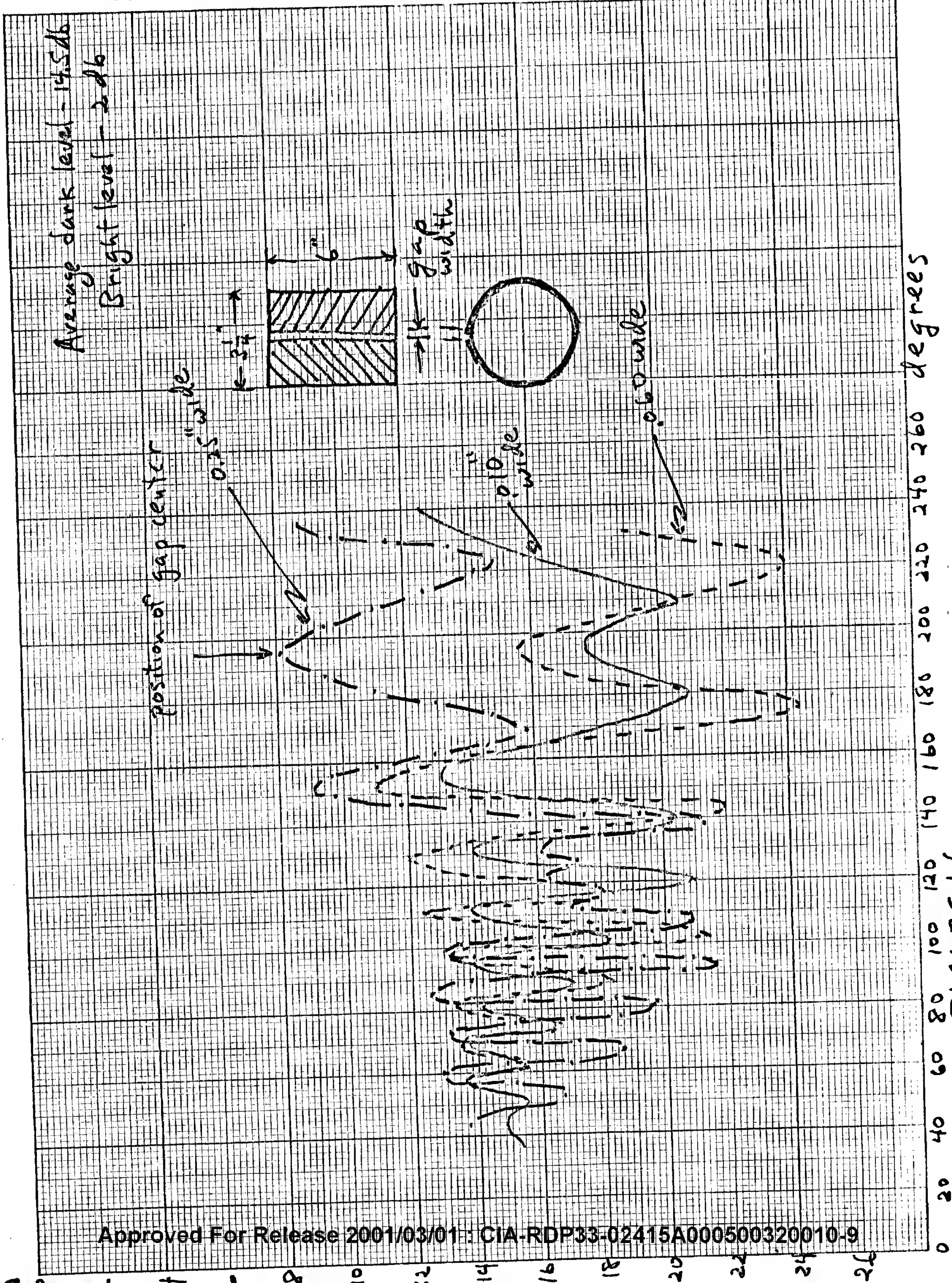
Average dark level - 14.5db
Bright level - 2 db
6"
3 1/4"
gap width
position of gap center
0.25" wide
0.10" wide
0.0" wide
degrees
0
20
40
60
80
100
120
140
160
180
200
220
240
260
0
2
4
6
8
10
12
14
16
18
20
22
24
26

FIGURE: 6